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and Resources
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Dear Mr. Hayden:

Subject: Pre-Engineering Assessments of an Enersolve Demonstration Project

We are enclosing nine (9) copies of the final report, previously approved by you.

With kind regards.

Yours truly,

Zafar A. Siddiqi
Project Manager

ZAS/fw
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TITLE

PRE-ENGINEERING ASSESSMENTS OF ENERSOLVE DEMONSTRATION PROJECTS

FINAL REPORT

BY

SNC INC.

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Principal Investigator : J.H. van Wijlen, Eng.

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada.

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SUMMARY

This pre-engineering survey is the Phase 1 of a 3-Phase Enersolve demonstration program which has as a target the conservation of energy by suggesting improvements in the operating efficiency.

The Foster Wheeler oil/bark fired boiler in the Kruger newsprint mill, Trois Rivières, was selected for investigation. This dual-fired unit offers the best potential in the steam plant for energy conservation.

The following recommendations have been proposed.

- Modification to the high pressure overfire combustion air system to improve the combustion process.

- Installation of gas burners in air ducts to raise combustion air temperature and fitting of a smaller spray tip on the oil gun.

- Updating of boiler instrumentation to improve the controls of the boiler process.

- Replacement of the hog fuel vibrating conveyor by a more effective bark distribution system which would also reduce air infiltration into the furnace.

- Replacement of the pneumatic hog fuel distributors by mechanical fuel spreaders to provide more even spreading of the bark on the grate.

- Installation of castable refractory on the inside furnace walls up to six feet high above the grate to provide a hotter combustion zone in the furnace.

It has been estimated that the upgrading of the facilities would result in approximate heat savings of 3.52 million kJ/h or $165,000 per year at a cost of $770,000. A gross return of 21% would be realized on capital expenditures based on energy savings only.

RESUME

Cette étude préliminaire est la phase 1 du programme Enersolve réparti sur 3 phases, qui a pour but de trouver des moyens d'améliorer un système à combustion afin d'économiser l'énergie.

Nous avions choisi pour fin d'études les installations du fabricant de papier journal Kruger de Trois-Rivières qui fonctionnent avec une chaudière à l'huile/écorce fabriquée par Foster Wheeler. Cette chaudière à combustion double offrait le plus de possibilités pour l'économie d'énergie.

Nous avons donc recommandé de faire les changements suivants:

- De modifier le mécanisme de la distribution de l'air à haute pression situé au-dessus du combustible afin d'améliorer son rendement.
- D'installer des brûleurs à gaz dans les conduites d'air afin d'augmenter la température de l'air pour la combustion; et d'installer un atomiseur plus efficace aux brûleurs d'huile.
- De rénover le système d'instruments de la chaudière pour en assurer un meilleur contrôle.
- De remplacer le convoyeur vibrant pour les déchets de bois écrasé par un système d'alimentation plus efficace qui réduirait en même temps la quantité d'air qui s'infiltre dans la chaudière.
- D'installer un épandeur mécanique à la place du distributeur pneumatique de déchets de bois pour assurer une meilleure répartition de l'écorce sur la grille.
- D'installer une couche réfractaire coulée à l'intérieur de la chaudière jusqu'à une hauteur de 6' au-dessus de la grille afin d'augmenter la température dans la zone de combustion.

Nous avons évalué que la demande énergétique de la chaudière, ainsi améliorée au coût de 770.000$, résulterait en une économie d'environ 3.52 millions kJ/h ou 165.000$ par année. Ces économies d'énergie représenteraient à elles seules 21% brut de l'investissement dont on fait ici mention.

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1.0 INTRODUCTION

1.0 INTRODUCTION

The present work was carried out for CANMET, Energy Research Laboratories, under the Contract No. OSQ83 through Supply and Services, Canada, Ottawa, entitled "Pre-Engineering Assessments of Enersolve Demonstration Projects".

The ENERSOLVE program under which the present project is carried out is concerned with reducing dependence on fossil fuels and other forms of purchased energy for industrial boilers and greater reliance on the use of self-generated fuels such as woodwaste. The objective of this survey is to demonstrate how energy savings can be made by making improvements of the bark burning facilities and methods on the Foster Wheeler boiler selected for this study.

The pulp and paper industry is energy-intensive. The high cost of purchased energy has resulted in an on-going effort in the paper industry to improve energy efficiency.

The specific boiler selected is one of four power boilers in the Kruger newsprint mill in Trois Rivières. The study is divided into three phases. These phases are as follows:

Phase I - Present pre-engineering survey.

Phase II - Detailed engineering plan for modification and costs for Phase III.

Phase III - Retrofit of equipment, commissioning and acceptance by the owner of upgraded systems.

This report deals with Phase I of the work

2.0 FACILITY DESCRIPTION

The Kruger newsprint mill is located in Trois Rivières, Québec. The Foster Wheeler boiler, installed in 1958, is the subject of the present investigation.

The boiler is a conventional balanced draft, two-drum bottom-supported unit equipped with a travelling grate. The unit consists of a water-cooled furnace, boiler bank and tubular air heater followed by a dust collector. A side view of the boiler is shown on drawing No. 1 in Appendix 3.

The boiler was originally designed to generate 56 tph (125,000 pph) of saturated steam at 200 psig from coal and/or oil, and 45 tph (100,000) pph from bark. The coal burning facilities have been removed and the unit is currently operating on bark and supplementary oil. Since the bark obtained from the wood room has a relatively high moisture content, ranging between 60 and 70% on a wet basis, one oil gun is engaged at all times to support bark firing and to prevent any blackouts which may otherwise result from operating high-moisture wood fuel.

The bark produced in the wood room is presently supporting steam generation in a range of 18 000 to 27 000 kg/h (40 000 - 60 000) pph steam. The mill has indicated that all drum barkers in the wood room will be converted in the near future from "wet" to "dry" debarking which should result in bark with lower moisture content and consequently in improved boiler efficiency.

Bark is presently conveyed from the wood room to a large wood refuse silo adjacent to the boiler room. Dewatered sludge from the mill's clarifier is mixed with the bark in the silo. Bark from the silo is fed to a vibrating conveyor which divides and discharges the bark to four boiler chutes. Pneumatic bark stokers deposit the bark on the travelling grate in the furnace. One forced draft fan and one booster fan supply preheated combustion air to the furnace. The ID fan evacuates the flue gases from the boiler to the stack.

The boiler is presently operated at a fairly steady supply rate of bark, steam output is not governed by the boiler plant master control.

Instrument readings and controls on the boiler are very basic by today's standards and make proper testing of the unit difficult. Currently the following measurements are provided: flue gas tempertures to and from air heater, air temperature leaving air heater, drum level, steam flow, flue gas opacity in stack, flue gas O_2 and furnace pressures. Recorders and indicators such as for undergrate air pressures were provided, but are presently no longer operable.

3.0 REVIEW OF MODIFICATIONS

3.0 REVIEW OF MODIFICATIONS

General

The purpose of this study is to propose modifications to the FW boiler and ancillaries in order to improve boiler efficiency on bark firing which in turn would result in larger steam production from bark. Approximately 4.5 tph (10,000 pph) of steam generated in the FW boiler is produced from oil, this is approximately 20% of the total steam flow from this unit. Any increase in steam generation from bark would result in a corresponding decrease of oil consumption in the steam plant, and would therefore reduce dependence on purchased fossil fuels.

We have investigated seven areas in the boiler installation where modifications have the potential to enhance the boiler efficiency. These areas are:

- Combustion Air System
- Combustion Control
- Bark Feed System
- Wood Fuel Distributors
- Refractory
- Boiler Blowdown System
- Casing Insulation
- Bark Drying System

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Combustion Air System

The combustion process in the furnace would be improved by having effective combustion air distribution and uniform fuel spreading in the hearth of the boiler unit. With any type of firing system in bark burning boilers there are normally at least two levels of air admission. The first level is undergrate air introduced through the bottom grate in the furnace. A thin even layer of bark and even distribution of air across the whole grate must be provided to achieve efficient combustion. The second level of air admission is overfire air introduced through air nozzles in the front and rear walls of the furnace. 15-50% of combustion air at 250-750 mm wg (10-30" wg) pressure, depending on the particular design, is usually

introduced to assist in creating proper turbulence and to accelerate the combustion process of the bark fuel in the lower part of the furnace.

In the present arrangement both low-pressure combustion air from the FD fan and high-pressure air delivered by a booster fan are available. Combustion air is supplied through two air ducts to both sides of the sifting hopper below the grate bed. High pressure air is presently introduced through a row of air nozzles in the arch of the back wall and through the wind-swept spouts of the pneumatic hog fuel spreaders. The low-pressure air system introducing combustion air through the grate bed via the sifting hopper would not be altered.

We would recommend that the present air temperature of approximately 180°C (350°F) be increased to 260°C (500°F) maximum. This high temperature would assist in the drying and combustion of the wet hog fuel. We assume the grate blocks are made of cast iron. If the blocks are made of alloy steel, then air temperature should be raised to 320°C (600°F). The additional heating of combustion air would be done by gas burners designed to be installed in the air ducts. The heat energy added to the combustion air would be compensated by oil firing reduced by approximately 25% with a smaller size spray tip on the oil gun. The net result of hotter combustion air and reduced oil firing would be improved combustion efficiency without increase of consumption of purchased fuel.

High-pressure air supply through a series of high-pressure air nozzles in the front and rear walls at, say, 3600 to 4300 mm (12 - 14 ft) above the bed would be desirable to penetrate the gas stream and to induce gas turbulence in the furnace. A series of eight 125 mm (5 inches) diameter high-pressure air nozzles at approximately 35° angle with the vertical would be provided in the front wall of the furnace. These nozzles would be fitted at an elevation where the pneumatic feeders were located originally. Manual dampers in each air nozzle to regulate the air pressure would be provided. Air nozzles in the rear wall of the furnace at a sufficient height above the fuel bed could only be installed if the cavity behind the low arch would be enlarged in height from the present low triangle shape. The rear wall tube bank forming one sloping side of the cavity and connected to the mud drum would be cut and replaced by a panel of waterwall tubes sloping upwards at a steeper angle from the mud drum to about midway point of the furnace rear wall, thus increasing the height of the cavity and allowing the new plenum for the

overfire air ducts to be installed. Present low-level air nozzles in the arch would be removed and replaced by a set of eight 125 mm (5 inches) diameter high pressure air nozzles to be located in the upper area of the cavity and angled downwards to the bed. These nozzles would also be dampered to regulate air flow and velocity. An air pressure of 250 to 375 mm (10 - 15 inches) wg would probably be best suited for this size of nozzles. The proposed arrangement is shown on drawing No. 4 in Appendix 3. We would recommend that the travelling grate, now operated intermittently, be operated in the same mode in the future.

Combustion Control

Efficient combustion control can only be achieved by properly monitoring and controlling the combustion process. All of the existing controls with the exception of the 0_2 analyzer and the opacity meter are obsolete and should be replaced.

Provision should be provided for the addition of instruments to monitor and control the process: flow meters to measure air flow to the various points of introduction into the boiler; steam flow from the boiler and oil flow to the boiler; temperature transmitters to monitor all air; flue gas and steam temperature; pressure transmitters to measure furnace; duct and drum pressures; control drives dampers and valves as required to control flow of air and fuel to boiler and flue gas from boiler; controllers; recorders and indicators to remotely monitor and control the combustion process. Drawing No. 2 in Appendix 3 shows the basic controls.

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Bark Feed System

In the present arrangement a vibrating conveyor distributes the bark flow to the four inlet chutes at the furnace. The distribution, however, is uneven and does not allow uniform fuel spreading on the grate.

To improve bark distribution to the four chutes, we would propose a bark supply system which would distribute the bark fuel evenly to all four chutes. The proposed bark feed system, shown schematically on drawing No. 3 in Appendix 3 would consist of a feed bin and two distribution conveyors, side by side. The two distributing screw conveyors, on reverse pitch, would convey the bark to four feeder screws discharging into the boiler chutes. The feeder screws would remain

filled with bark, thus preventing air infiltration into the furnace and hereby reducing heat losses in the flue gas. A bin high-level sensing device would automatically stop the feed belt conveyor to the feed bin whenever the bin is full.

Wood Fuel Distributors

We have observed that the bark fuel is deposited on a pile in the furnace and it can be concluded that the pneumatic fuel distributors are not effective in spreading the fuel on the grate. We would propose that the pneumatic fuel distributors be replaced by mechanical spreader stokers. The distributor paddles would spread and evenly distribute the bark fuel over the grate providing the bark is properly shredded and not long and stringy, and providing the moisture content of the bark is fairly constant.

Refractory

It would be beneficial to the combustion process if the temperature in the lower hearth above the bed were as high as possible especially in this case where high-moisture fuel is fired. Castable refractory applied on the water walls up to 1800 mm (6 ft) from the bed would reflect heat on to the bed and greatly assist the drying process of the bark fuel.

Boiler Blowdown

Make-up feed water to the boiler is treated in zeolite softeners. The blowdown rate of approximately 5 percent would indicate that the water treatment is satisfactory and any modifications here would not be justified. A blowdown heat exchanger recovers some of the heat in the blowdown water. The heat exchanger will be replaced shortly by a larger unit to improve heat extraction from blowdown water.

Casing Insulation

A simple method of checking heat loss through boiler casing insulation is measurement of temperatures by touch. Hot casing temperatures are indicative of excessive radiant heat loss from the boiler. Outside casing temperatures were

judged to be below 60°C (140°F) which is acceptable for providing comfortable working conditions in the boiler area and keeping radiant heat loss from the unit to a minimum.

Bark Drying

A retrofit bark drying installation utilizing the heat in flue gas to dry the bark to, say, 40 percent moisture content would enhance the boiler efficiency by driving off a percentage of moisture in the bark before the bark is discharged into the furnace. However, bark production in the mill, in the range of 9 to 13.6 tph (20,000 - 30,000 pph) "as fired", is relatively low. Energy savings would not justify a bark drying installation at a cost in excess of $1,000,000.

4.0 ESTIMATES OF HEAT SAVINGS

4.0 ESTIMATES OF HEAT SAVINGS

We have made calculations of heat savings in Appendix 2 resulting from the reduction of the excess combustion air flow from the present 85 percent approximately to an estimated 50 percent. 50 percent excess air would be attainable if the proposed modifications are implemented. The reduction of excess air would result in proportional reduction of flue gas flow to the stack thereby decreasing heating losses from product gas.

Based on an oil price of $32/bbl and 8 000 hours per year operation, the estimated energy savings are 3,520,000 kJ or $165,000.

5.0 ESTIMATED BOILER HEAT LOSSES

5.0 ESTIMATED BOILER HEAT LOSES

The estimated heat losses from boiler operation under present operating conditions are 45,5% and consist of dry gas losses, H_2O and H_2 in fuel, unburned combustible, radiation and manufacturer's margin. A summary of heat losses is presented in Appendix 3.

The fuel heat input to the boiler consists of heat from bark fuel and heat from supplementary oil. The heat input to the boiler minus losses in the flue gases (heat and water vapour), unburned combustibles, boiler radiation and margin determines the boiler efficiency. The estimated efficiency of 54.5% is low however, this can be expected from a boiler operating at very high combustion air supply (85% excess air). It can be noted from the table in Appendix 3 that reduction of flue gases and/or reduction of moisture content of the bark would improve boiler efficiency.

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6.0 ESTIMATES OF PROJECT COSTS

6.0 ESTIMATES OF PROJECT COSTS

Costs for Phases I, II and III

The estimated cost for the three Phases are as follows:

Phase I The cost of present pre-engineering survey is $15,000.

Phase II The estimated costs for carrying out the detailed engineering for retrofitting and upgrading boiler is $75,000 spread over a period of 7 months. The preliminary schedule for engineering and construction is shown in Figure 1.

Phase III The retrofitting of the boiler and supporting equipment are described under Review of Modifications. The capital cost estimates for carrying out this work, including engineering charges at $75,000, would be $770,000. The itemized cost for retrofitting the boiler and supporting systems is given in Table 1.

Table 1 - Capital Cost Estimates

Bark Feed System and Structures	$ 235,000
Combustion Control Equipment	164,000
Hog Fuel Distributors	58,000
Overfire Air System	28,000
Refractory in Furnace	14,000
Retrofit Furnace Rear Wall	94,000
Sub-Total	$ 593,000
Construction Overhead, Engineering and Contingencies	177,000
Total Installed Costs	$ 770,000

ACTIVITIES	MONTHS						
	1	2	3	4	5	6	7
REVIEW OF REPORT							
ENGINEERING DESIGN							
EQUIPMENT SPECIFICATIONS							
CONSTRUCTION BUDGET							
EQUIPMENT DELIVERY							
RETROFIT ACTIVITY							
BOILER SHUTDOWN							
START-UP							

PROJECT SCHEDULE

FIGURE I

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KRUGER MILL - TROIS-RIVIERES
F. W. BOILER
CONSTRUCTION SCHEDULE

ENERSOLVE PROGRAM

STANDARD

REV.

PROJECT M-6463

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Basis of Estimates

The capital costs estimates for retrofitting the boiler and supporting equipment are based upon budget prices obtained from suppliers and on data from Sandwell files for similar work. Equipment estimates include supporting structures, installation labour and freight.

An allowance for escalation of costs due to the effects of inflation has not been included.

The accuracy of the cost estimates is $\pm$ 20%.

The estimated costs for Phase II and Phase III of the study consisting of the engineering, upgrading of the boiler and auxiliary equipment, construction overhead and contingencies are $770,000.

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7.0 CONCLUSIONS

7.0 CONCLUSIONS

We expect that steam generation from bark would be improved by better spreading of the bark fuel on the grate, by upgrating combustion control and flow measurements, by efficient use and additional heating of undergrate combustion air and high pressure overfire, and by restricting inleakage of air into the furnace.

The projected reduction of present excess combustion air from 80-90% to 50% is a conservative target and should be attainable by upgrading the boiler and ancillary equipment as described in this report. If in future operations excess air could be reduced further to 40% on a regular basis, then annual heat savings would reach $200,000 from $165,000 at 50% excess air.

The estimated installed cost for the work is $770,000. Gross return on investment, based on $165,000 annual heat savings, would be 21%.

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APPENDIX 1

GLOSSARY OF TERMS

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APPENDIX 1 - GLOSSARY OF TERMS

bbl	Barrel
FD	Forced Draft
h	Hour
ID	Induced Draft
kJ	kilojoules
kg/h	kilogram per hour
M	Million
m	Meter
mm	Milimeter
m.c.	Moisture content
pph	Pounds per hour
tph	Metric ton per hour
wg	Water gauge
yr	Year

APPENDIX 2

POTENTIAL SAVINGS FROM RETROFIT BOILER

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APPENDIX 2 - Potential Savings From Retrofit Boiler

1. General Data Obtained from Mill Records

		Units	Amount
Steam generated	- summer	kg/h	25 000 - 36 000
	- winter	kg/h	18 000 - 27 000
	- yearly average	kg/h	27 000
Steam from bark	- yearly average	kg/h	21 000
Moisture content - bark		%	65
Heating value of bark at 65% m.c.		kJ/kg	6 960
Bark flow, as fired		kg/h	16 900
Excess air at 10% O_2 in flue gas		%	85
Flue gas temperature		°C	240
Excess air after modifications - estimate		%	50

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2. Present Operation - 85% Excess Air

	Units		Amount
*Weight combustion air at 85% excess air	$kg/10^6$ kJ		580.5
Weight of wood	$kg/10^6$ kJ		150.5
Flue gas weight	$kg/10^6$ kJ		731
Moisture in wood	$kg/10^6$ kJ		98.9
Moisture from combustion H_2	$kg/10^6$ kJ		34.4
Total moisture in gas	$kg/10^6$ kJ		133.3
Dry gas weight (731-133.3)	$kg/10^6$ kJ		597.7
Heat from bark	10^6 kJ/h		117.625
Weight of dry flue gas (597.7 x 117 625)	kg/h		70 300
Flue gas temperature	°C		240
Heat loss in dry gas 70 300 x 1.13 (240-28)/10^6	10^6 kJ/h		16.84

3. Future Operation - 50% Excess Air

Weight combustion air at 50% excess air	$kg/10^6$ kJ		455.8
Flue gas weight	$kg/10^6$ kJ		606.3
Dry gas weight (606.3 - 133.3)	$kg/10^6$ kJ		473
Heat from bark	10^6 kJ/h		117.625
Weight of dry flue gas	kg/h		55 640
Heat loss in dry gas	10^6 kJ/h		13.32

4. Calculations of Heat Savings

Reduction in flue gas losses 50% versus 85% excess air (16.84 - 13.32)	10^6 kJ/h		3.52
Cost of oil	$/bbl		32
Cost of heat from oil	$/$10^6$ kJ		5.87
Annual operating hours	h/yr		8 000
Annual heat savings	$/yr		165 300
	$/yr	say	165 000

*For reference calculation methods see C-E hand book Fossil Power Systems

APPENDIX 3

ESTIMATED BOILER HEAT LOSSES

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APPENDIX 3 - Estimated Boiler Heat Losses

(present operating conditions)

Item		Units	Amount
Bark flow		kg/h	16 900
Heat value of bark, 65% m.c.		kJ/kg	6 960
Heat in wood fuel		106kJ/h	117.63
Heat in fuel oil		106kJ/h	15.38
Total heat input to boiler		106kJ/h	133.01
Flue gas weight		kg/h	86 130
Total moisture in flue gas		kg/h	15 710
Dry flue gas weight		kg/h	70 420
Heat loss in dry gas		106kJ/h	16.95
Heat loss in moisture		106kJ/h	40.08
Heat loss - Dry gas	16.95 / 133.01	%	12.7
- H_2O and H_2 in fuel	40.08 / 133.01	%	30.1
Unburned combustibles		%	.5
Boiler radiation		%	.7
Manufacturer's margin		%	1.5
Total heat losses		%	45.5
Estimated boiler efficiency		%	54.5

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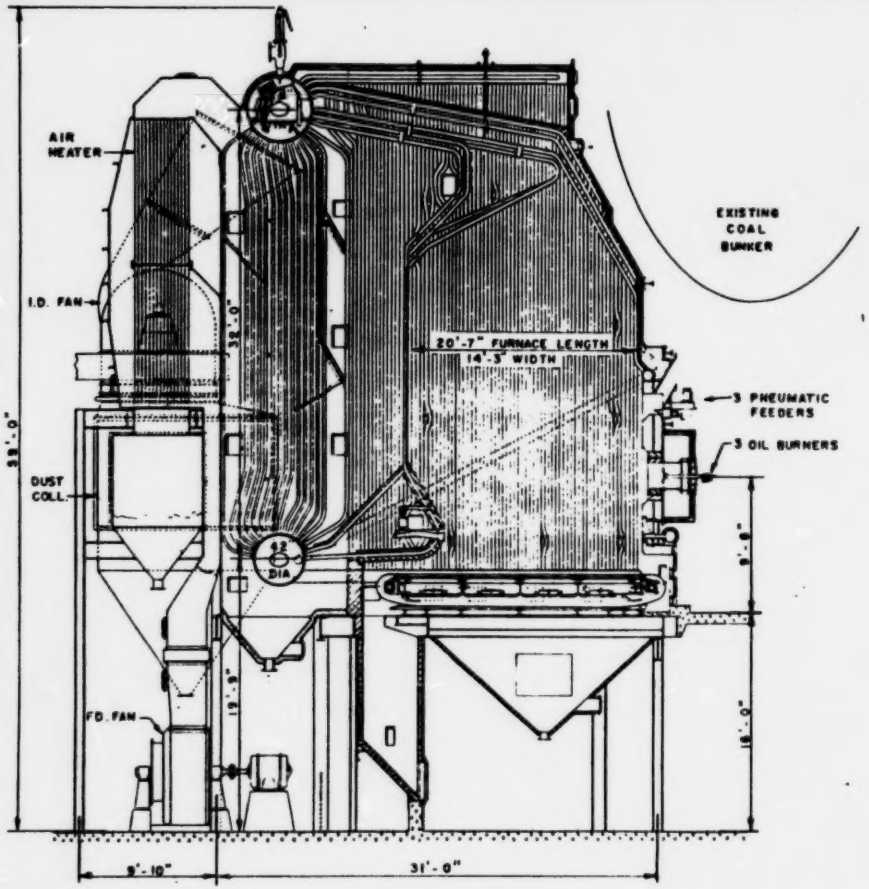
APPENDIX 4

ILLUSTRATIONS



SCALE — 1/8" = 1'-0"

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KRUGER MILL TROIS RIVERES
BOILER
SIDE VIEW.

ENERSOLVE PROGRAM

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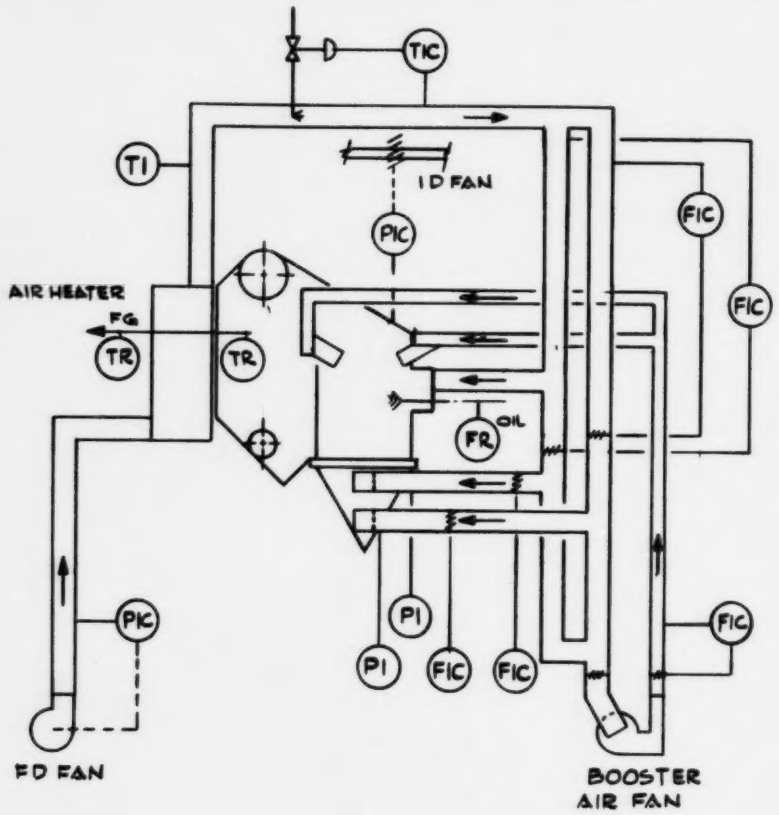

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KRUGER MILL TROIS RIVIERES
BOILER CONTROLS
BASIC SCHEMATICS

ENERSOLVE PROGRAM

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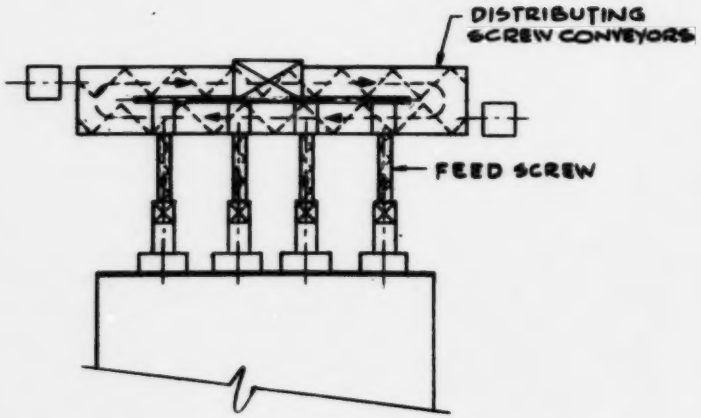
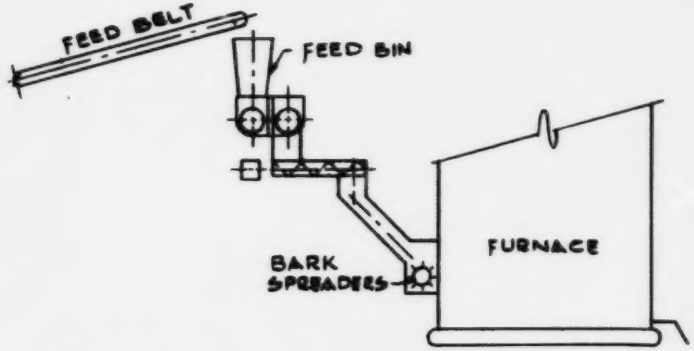


PLAN VIEW



SIDE VIEW

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DATE

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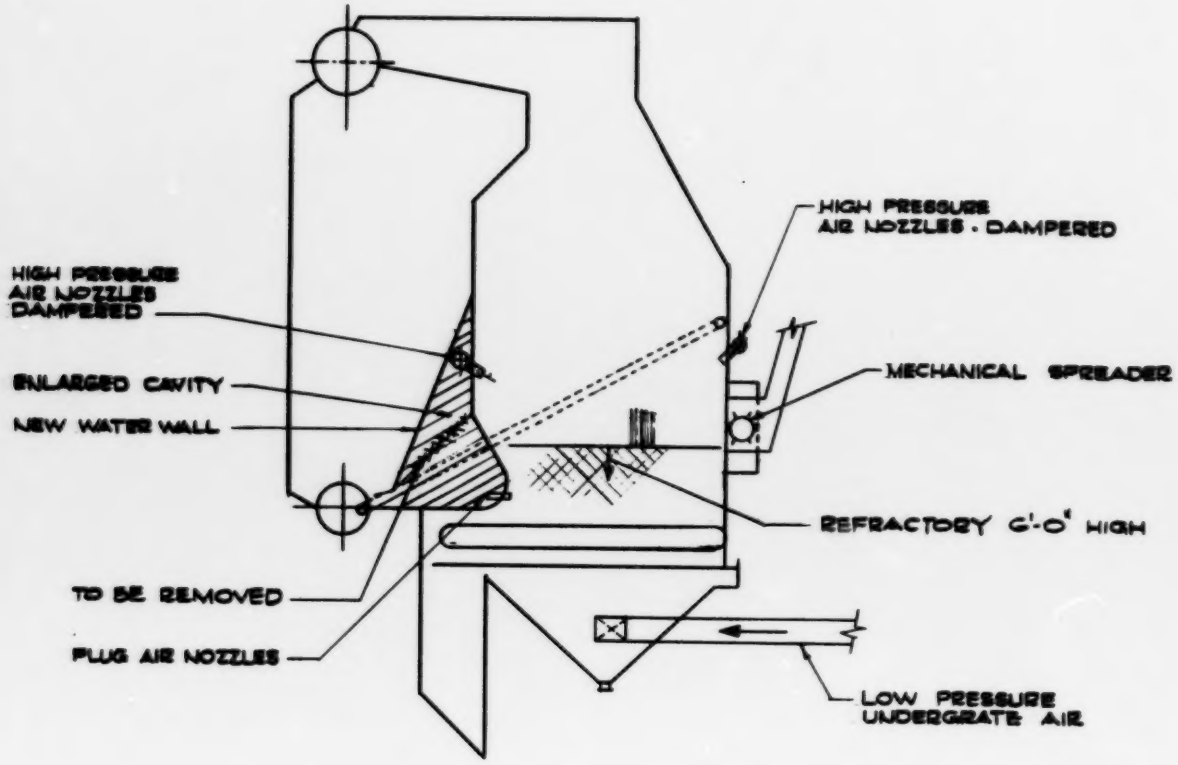
KRUGER MILL - TROIS RIVIERES
BARK HANDLING SYSTEM
SCHEMATIC ARRANGEMENT

ENERSOLVE PROGRAM

MG463-3 REV.



REF	DWG.	TITLE	REV	ISSUE STATUS	APP	DATE

APPROVED

DATE 15 MAR '84

MG4G3-4

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SCALE	—			
DRAWN	R.C.	15	3	84
CHKD				
APP'D				
APP'D				

Sandwell

KRUGER MILL TROIS RIVIERES
FURNACE RETROFIT
SIDE VIEW

ENERSOLVE PROGRAM

MG4G3-4 REV.